International Journal of Recent Engineering Science (IJRES)
ISSN: 2349 – 7157 / doi: 10.1445/23497157/IJRES-V5I2P105
Volume 5 Issue 2, 21-26, Mar-Apr 2018

Review on Energy Efficiency Green Data Centers

Amarnath V, Mallikarjuna K, Nagendra J, Umesha D M, Nalina V
Department of Information Science and Engineering, BMS College of Engineering, India

Abstract

E*arly computation has more problems in various business areas; thus, new storage power called data centers evolved. The current computing on the internet stands with the help of Datacenters. Data centers are the heart of computing and internet services. Currently, the data centers workload is increasing to satisfy the customer needs that indirectly contributed to the massive energy and resulted in consuming large amounts of electricity. The current problem in the world is global warming; this is caused due to the emission of carbon and power consumption of data centers. To reduce these carbon footprints, many data centers have decided to power the data center with renewable energy. Where the usage of this renewable energy leads to an increase in operating cost and maintenance cost. Thus Power saving remains the central problem in the current world. The solving of these problems evolved with the interest of designing many frameworks required with energy efficiency. In this paper, we have addressed the challenges and problems facing by the data centers and the importance of green IT. Various techniques and methodologies used for making the data center efficient have been analyzed in order to make still the data center efficient for achieving green IT.*

Keywords - *Green IT, Service Level Agreement (SLA), DVFS (power and speed settings for processor), Autonomous computing, Power consumption.*

I. INTRODUCTION

The environment that involved in the creation of sustainable development in IT is referred to as green computing. It is the responsibility of each person to make an eco-friendly environment. In broader terms, Green IT is "the study and practice of designing, manufacturing, using and disposing of computers, servers, and associated subsystems." The aim of green IT is to use eco-friendly products for the development that increases the lifetime of the product, and also, the products should be able to reuse for future use and easy to dispose of, and does not cause any harm to the environment.

The cause that required for making greener is the increasing prices in all fields that are due to the more consumption of resources and the impact by this situation is high on the environment, power consumption by the devices like servers, computers, monitors, the device used for communications in a data center, data centers cooling system and increased numbers of computers and their use has made a massive impact on the environment. Many steps have been taken to reduce these impacts by making IT environmentally friendly through its life cycle. So Industry and Enterprise are now interested in creating new products and methods that will help to solve the environmental issues and provide a new chance to develop green products. Whereby this practice, we can make the entire component green products and encourage green IT. The essential products that should be made greener are Personal PC, notebooks, large servers in data centers, and computing. The main key component among them is Datacenters.

Data centers are becoming increasingly popular for the provisioning of computing resources. Along with the increasing Internet services and cloud computing in recent years, the modern engine rooms in Enterprise data center the power and computing that requires internet corporate are growing in their number, capacity, and power consumption. The amount of carbon dioxide release of the data centers has been highly increased factor as they consumption of power for computing in IT and cooling systems for various servers in data centers, Hence the negative impacts on the environment is created, and power associated with data centers operations have been surging significantly. Thus the increased operating cost and colossal energy consumption lead to a harmful impact on the environment; in the last few years' server requests for more electricity usage than the earlier models in the data centers. When the data centers expandability is more, the necessity of the electrical power is more than the regular use that is currently use. The current challenge involves reducing power consumption when extensive data and applications use the data centers for their storage. According to the statistics, none of the current data centers like Apple, Google, Microsoft, and yahoo [14] is not free from the harm full attack and Green at all. The power consumption by the data centers is as shown below.

Table 1: Energy consumption in recent years

Energy level in Data centers	Year
20KW	2000
60KW	2004
100KW	2008
180KW	2014
189KW	2016

In the past few years, the data centers c in the US consumed an estimated 70 billion kilowatt per hour, representing about 8% annual consumption of US power consumption. From 2015-2017 the energy consumption increased by 15% each year, resulting in a near doubling of servers operating in data centers where the only solution is Green computing, so the data centers must become greener.

Where the green initiative has been taken in data centers for the usage of eco-friendly resources to establish

an efficient network in reducing power, the flexible and adaptable code of conduct encourages the current owners to adopt the energy efficiency practices for their data center to reduce the power consumption. The following four approaches can be applied to promote green computing they are Green use, using the devices and peripherals in an eco-friendly manner, Green disposal reusing the existing system and removing the unwanted components, Green design and Green manufacturing and practices like reuse, refurbish of components and recycling techniques can also be used. However, these approaches work for only small data centers. In this paper, we study the techniques and framework proposed for making Green It and improve energy efficiency and DC.

The paper consists of a section as follows. Section II consists of a Literature survey; Section III consists of Existing methodology, Section IV with Proposed methodology, and finally Section V. with a conclusion.

II. LITERATURE SURVEY

Dilip D. Kandlur et al. [1] investigated the new solution for microprocessor and system design, and the experiment is done for data centers with some of the approaches like "just open the windows" approach to reducing the power usage in the cooling devices. The greening of data centers is done on various devices like computers, Monitoring systems, Computing systems, and storage systems. The new microprocessor chips like system with multi-core for POWER6 and POWER7 computer processor. Was introduced to balance power by featuring not only to the chip but also the entire system, Where IBM's power 6 was the first microprocessor chip for the power reduction scheme and the systems deploy power reduction power supply protection by the feature called "turbo" frequency where it increases to delivering power reductions and achieve saving and "zero-emission data centers" refers to cooling solutions with a liquid consisting of 5ddegree cooling that makes to consume 5 degree Celsius. Furthermore, a rack of blades arrangements; this technique is scheduled for power savings. IBM has applied this approach that resulted in a savings of 20% power consumption.

Dzmitry Kliazovich et al. [2] proposed a methodology called DENS (Data centers energy efficiency network scheduling), the methodology that aims to balance between the individual job performance, requirements for job quality of service, and power consumption in system models. Moreover, the approach is designed to preventing hotspots inside the network and reduces the number of computing servers, where the network that includes energy efficiency and creation of knowledge of the network is determined by the introduction of the "feedback link channels" to minimize the number of computational and memory overhead. The methodology called "DENS" achieves the green efficiency by inserting the best fit resources for the network. Workload consolidations for power efficiency are achieved by preventing the number of computing servers. The reduction of computing servers from 1016 servers to 956 servers was achieved using this simulation. The simulations often resulted in the three-tier architecture to maintain the required level of QoS.

Anton Beloglazov specified some of the practices like energy-efficient hardware, terminal server and clients, and the methods like DVFS (Dynamic Voltage and frequency scaling). However, these methods are not much efficient, so forwarding of an efficient planned technique with factors like scalability and non-centralized algorithm for dedicated resource allocation and also more robust virtual machines that consist of more efficiency in power saving and concrete policies for resource sharing. The VMs components are dispatchers and managers for the system like internal and to the overall system, local managers that reside in system nodes as a virtual monitor (VMM). An approach like Cloud computing naturally leads to energy-efficiency, A reduction state of 66% compared to the regular system, which does not follow these virtual machine systems.

Hang Yaun et al. [4] provided a research review on multimedia with the help of cloud service. In which the communication of data done by the people on the internet consists maximum of 90% of multimedia data and thus leads to the consumption of more power by the server. The energy management in the data centers can be done by saving the energy in the server by installing 50% energy efficiency hardware than the current computing servers. Where the power is usually will be in 2 states called active and inactive, these can be controlled by low power active states and by implementing the DVFS scheduling with the hardware-based approach. Using the burdened energy management approach like cooling technique, thermal management (overheating and thermal imbalance) and power service, and making resource powerful. Where the efficiency of power reduction in a network, transmission can be reduced by optimizing routing protocols, the practice of avoiding the unnecessary insertion of traversing hops, and distribute the multimedia data across the various cloud.

Sandeep KS. Gupta et al. [5] provided a concept of "Green data center simulator" (GDC sim).The Simulator with more management techniques and physical behavior to be performed at data centers that include some of the critical features with components like Blue sim, resource management, and Simulator, where these components can be considered by the data center users while building up of the new data centers and existing data centers that require to be energy efficient.

Forough Norouzi et al. [6] presented promising solutions to manage complex computing systems in data centers by designing self-optimized data centers with the help of multi-level autonomic managers, trying to meet SLA objectives and ADC Simulator (Autonomic data center management)Simulator platform to analyze the collaboration blueprint of different managers with autonomic feature managers for saving the power in a data center that supports different type of simulators and

workloads and standardization of SLA violations in limited number.

R.Yamini provided the most heuristic technique to provide conscious energy efficiency, referring to the term known as the GREEN algorithm, where the method is used for the model called utility computing or cloud computing. The green algorithm is used not only for energy efficiency but also for excellent memory utilization. The energy efficiency can be achieved using DVFS (Dynamic voltage frequency scaling techniques and by resource allocation or virtual migration techniques and algorithmic approach. If this algorithm is used efficiently, the lowering of energy usage is achieved with lower pollution and power reduction to meet the lower energy usage for achieving green cloud computing [7].

Marta Chinnici et al. [8] proposed a methodology by analyzing many techniques and methodologies for increasing the savings technique used in data centers. Practices approached include- recycle and reuse techniques for the datacenter that changed the computation in society. The DC energy is calculated by Business as Usual(BAU) and a new data center(NDC).

Eugen Volk et al. [9] presented two leading optimizations or power reduction approach energy-efficiency optimization approach in the project of CoolEmAll that makes the current data center with rugged energy-saving coolers and devices. This technique enables the designer, operator to plan resource efficiency, and the approach also includes different categories of building blocks of the data center, Simulator, and SVD toolkit. The other type is Eco2Clouds, a new model for making the data centers resources with efficient application hosting and resources designing specific matrices like Resource Usage Matrix and Energy Matrices like Power Information Matrices, Energy Reduction Matrices(ERM), Heat Aware Matrices(HAM) with Green Matrices(GM) and Financial Matrices(FM).

Norhashimi Bin Mohd Nor et al. [10] presented a framework for the data centers stakeholders called "Data Centers Energy Reduction Framework(DCERF)" for the energy utilization and other concepts like The Green Data Center Alliance, that consists of a set of rules for "Energy-Efficient Data centers" and Powerful Four pillar framework for the benefit of the data center.

Hui Dou et al. [17] proposed a review that addresses how data centers can apply the methods for maximizing green energy utilization and reduce the budget for replacing resources. Furthermore, the algorithm evaluates real-time electricity prices, data center workload, and green energy availability traces.

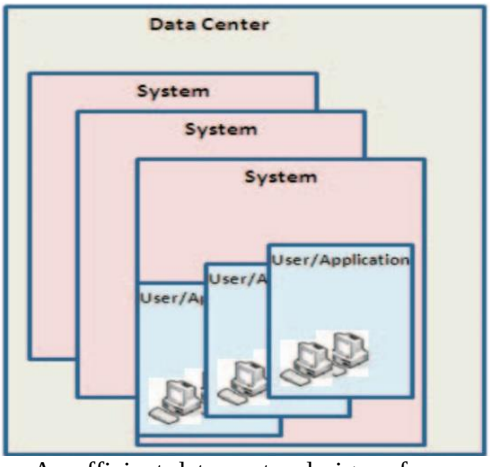
III. EXISTING METHODOLOGY

In the Existing scenario, the revolution started to achieve the energy degree at low in system-level and servers in the data center. The general states of the data center usually consist of two types "Active" and "Inactive." The energy efficiency is achieved in the server with methods like "Lowest power state" these states are identified with the advanced technology known as "Dynamic Voltage and Frequency Scaling (DVFS)." DVFS refers to controlling or adjustment of power and speed settings on computing devices, processors, and peripheral devices that can be used to optimize resource allotment for tasks and maximize power saving when the resources are required for other tasks. It also helps with reducing the device operating voltage to cut power consumption. DVFS is applied to the CPU during the phase of internal communications in the data center and loaded in the standard OS kernel with an advanced key to monitoring CPU power consumption status. Where it automatically predicts the runtime behavior of the applications and sets the power state to the processor. For system-level savings, put sleep mechanisms can be implemented in all systems to identify the inactive states.

The online multimedia streaming and sharing is the massive consumption of internet traffic where that leads to energy-performance trade-off in case of data storage, delivery, and performance. The energy optimization for the multimedia server system is done with the framework as specified in the figure-4[4] consists of workload prediction and performance modeling. 1) Workload prediction stops the new request by estimating the energy cost at the entry-level by the user access perspective. Moreover, performance modeling identifies the bottleneck associated.

The system architecture consists of a Power model, the Predicted workload, and a performance model with information like different constraints and different energy management techniques.

Fig 1: Energy Optimization for multimedia server system

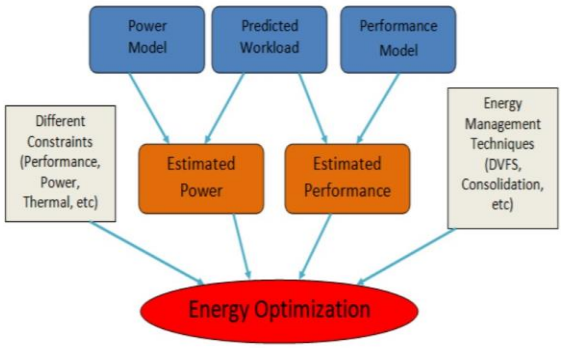


An efficient data center designer focuses on two types: 1) Physical design and energy-efficient cooling mechanisms. GDCSim is a simulation tool that concentrates on the green data centers that include key features like Automatic computing machines, Analytics design for online usage, Continuous design analysis, Thermal management, workload, and power management. Where the GDCSim includes 1).BlueSim that is inputted with "XML type specification" for performing CFD

simulation [15] for heat control.2) Resource management that makes cooling and reduces the workload by analyzing the behaviour and 3) Network simulator

Autonomic computing can also be used for making energy-efficient data centers with managing capability with the help of high-level objectives defined by the system administrator's objectives. The objectives include "self-configuring" and "self-optimization," where these autonomic managers can be achieved using the ADCM Simulator to support different types of system and workload in the data center. The Simulator supports Interactive based applications, Enterprise system and High configuration system. The data center hierarchy in the Simulator defined using top three levels of Data center hierarchy with System and User Application. Each level consists of different set of the computing nodes; the Simulator analyzes each level and assigns the required set of the computing nodes. Figure-2[6] explains the abstract model of ADCMsim.

Fig2: Abstract modal of ADCM Simulator



Secondly, for efficient cooling mechanisms, most of the data centers use blade architecture [16] consists of multiple blade servers that provide services such as cooling, power, and networking—a proper arrangement of blades in the rack with only required level. Based on the temperature, place only the required number of blades and adjust to all the blades in the rack. A progressive policy of CPU measuring can be implemented along with the efficient thermal management policies, and the determination of consumption of power at each level can be verified continuously.

Some of the frameworks need to be followed to make the data center efficiency. The frameworks are The Four pillar framework and EU code. The framework comparison to being done to analyze three different levels. Level 1 consists of the highest energy efficiency. Level-2 consists of medium energy-efficient and Level-3 for the lowest energy efficiency. The components are classified into different zones; they are Engineering and design methodologies in the Facility. Information technology process, Process, Governance, and practices. The below table is shown how the category is made [10].

Another technique used is a virtualization technology that allows for creating more virtual machines that can be implemented on the existing server where it minimizes the usage of hardware that is working in the database and makes the utilization of resources in an efficient way. In the current scenario, VM is used as the most required resources by the user.VM is the emulation of a computer that provides the functionality of the physical computer.VM is easy to move from one host to another host. Nowadays, the organization refuses to purchase the additional hardware for computation, resulting in increased expense to the data center. The latest paradigm for this is online storage computing that motivates achieving energy efficiency with increased resource utilization, adjustable to resources, and portability [12].

IV. PROPOSED METHODOLOGY

Since the cloud paradigm is the latest technique wherein this work, the underlying infrastructures are considered with cloud data centers consisting of n nodes; in this process, user requests for many resources from VMs. If the VMs is not able to give the requested resources, it leads to SLA violation (occurs when VM not able to provide requested resources). The system execution contains the following steps [3]

1. New request and response for process execution,
2. Dispatching and dropping VM requests for VM provisioning,
3. Connection between global managers
4. Information about the utilization of resources
5. Migration Commands
6. Commands for VM usage and power utilization, and 7. VM actions

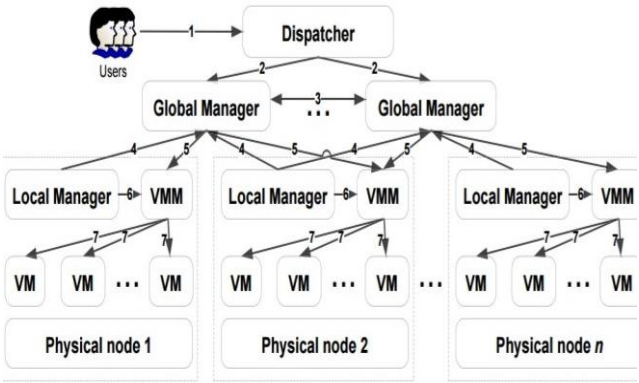


Fig 3: The implementation of Virtual Machines

The above figure represents the complete system architecture [3] of the implementation of the VMs. The 3 optimization stages do energy efficiency. In the initial optimization, the techniques used to utilize the resources and monitored, and VMs are made for reallocating for reducing the number of nodes. Secondly, communication between data VMs and third is cooling solutions.

Table 2: Efficient data center techniques for energy reduction

Sl. no	Proposed Technique	Ref no	Objective	Methodology	Results	Limitations
1.	Power 6 & Power 7 Microprocessor	1	To reduce energy usage by microprocessor	Installation of the efficient microprocessor in all systems	20% of the power consumption reduced	Only the system problem is solved in the data center
2.	DENS methodology	2	Maintaining a balance between three factors	Avoiding hotspots in the data center and providing network awareness with 3 tier architecture	Reduces the energy consumption by 4 % in the server, 2% in system 1% in switches	Still, high efficiency is required for a three-tier architecture
3	Distributed Multimedia service	4	To summarize the design technique for an energy-efficient data center	Suggest energy-efficient practices Control of multimedia data	Efficient CPU utilization with resource utilization	Involves performance penalties and overheads with additional schemes
4	GDC Simulator	5	Resource management for green data center	Automated processing, iterative design analysis and thermal analysis	Designing efficiently and standardizing the useful techniques	Maximum error rate of 7.7 % is observed in data center
5.	Autonomic energy efficient	6	To develop holistic Simulator that supports entire data center	By Autonomic managers in all system by meeting SLA requirements	Usage of Optimum number of servers and minimum energy consumption	Difficult to manage SLA violations
6.	Algorithm for making green	7	To decrease the pollution rate and the amount of CO2	Consolidation algorithm for achieving task conscious like ECTC and Max util	Lower source usage with energy savings with 18% increase	More energy consumption when migration is not considered
7.	Green data center framework	10	To reduce data center energy consumption	Framework models guidelines and terminologies	80% impact on energy efficiency in data centers	More attributes are required Flexible for huge investors
8	EU projects CoolEmAll and Eco2clouds	9	To build energy-efficient data centers and optimize energy efficiency	Data center efficiency building blocks and SVD toolkit	Efficient utilization of the available resources	Only efficient in Games projects

V. CONCLUSION

The increased purpose of using more computing resources resulted in creating the data centers in large quantities. The production of this massive data center resulted in protecting these resources. The power usage by the data centers is increasing along with the usage of more advanced resources with increasing carbon footprint produced by the data center. For example, the Google data centers 260 million watts consumption of 0.01% of the world's energy. So the critical situation for the data centers to make green utilization of energy; however, green energy costs more than brown one.

So in this paper, we surveyed many techniques used for energy consumption modelling and prediction for data centers. We have considered many techniques, frameworks algorithms, and virtualization techniques to reduce the carbon footprint and it is implemented in such a way that they have resulted in the actual decrease in energy consumption and increase in energy-performance reduction in the production of carbon dioxide is an important task to make the energy-efficient data centers.

For this purpose, we have reviewed [table2] several techniques that can lead to the efficiency of data centers and the usage of virtualization of servers for achieving energy efficiency. In the future, the research area could be in addressing the limitations of these techniques and reducing the CO2 emissions, optimization of resources, and cost for the data centers.

REFERENCES

[1] Dilip D. Kandlur; Tom W. Keller," *Green data centers and hot chips*," Proceedings of the 2009 46th ACM/IEEE Design Automation Conference, pp 888 – 890,2009, IEEE Transactions.

[2] Dzmitry Kliazovich; Pascal Bouvry; Samee Ullah Khan, "*DENS: Data Center Energy-Efficient Network-Aware Scheduling*", IEEEConferences, pp 69-75, 2010.

[3] Anton Beloglazov; Rajkumar Buyya "E*nergy Efficient Allocation of Virtual Machines in Cloud Data Centers*," 2010 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, pp 577-578,2010.

[4] HangYuan; C.-C.JayKuo; Ishfaq Ahmad," *Energy efficiency in data centers and cloud-based multimedia services An overview and future directions*," International Conference on Green Computing, pp 375-382. 2010.

[5] Sandeep K. S. Gupta; Rose Robin Gilbert; Ayan Banerjee; Zahra Abbasi; Tridib Mukherjee Georgios Varsamopoulos, "*GDCSim: A tool for analyzing Green Data Center design and resource management techniques*", 2011 International Green Computing Conference and Workshops,pp 1-8, 2011.

[6] Forough Norouzi; Michael A. Bauer, "*Toward an Autonomic Energy Efficient Data Center"*, 2012 IEEE International Conference on Green Computing and Communications,pp 487-493, 2012.

[7] R. Yamini, *"Power management in cloud computing using green algorithm,*" IEEE-International Conference On Advances In Engineering, Science And Management (ICAESM -2012), pp 128-133, 2012.

[8] Marta Chinnici; Andrea Quintiliani, "*An Example of Methodology to Assess Energy Efficiency Improvements in Datacenters*", 2013 International Conference on Cloud and Green Computing, pp 459-463, 2013.

[9] Eugen Volk; Axel Tenschert; Michael Gienger; Ariel Oleksiak; Laura Sisó; Jaume Salom," *Improving Energy Efficiency in Data Centers and Federated Cloud Environments : Comparison of CoolEmAll and Eco2Clouds Approaches and Metrics"*, 2013 International Conference on Cloud and Green Computing, pp 443-450, 2013.

[10] Norhashimi Bin Mohd Nor; Mohd Hasan Bin Selamat." *Review on green data center frameworks*",2014 4th World Congress on Information and Communication Technologies (WICT 2014), pp 338-343, 2014.

[11] Mohammad Javad Abbasi, Mehrdad Mohri, "*Scheduling Tasks in the Cloud Computing Environment with the Effect of Cuckoo Optimization Algorithm*" SSRG International Journal of Computer Science and Engineering 3.8 (2016): 1-9.

[12] Sanjeevi P; Viswanathan P, "*A green energy optimized scheduling algorithm for cloud data centers"*, 2015 International Conference on Computing and Network Communications (CoCoNet), pp 941-945, 2015.

[13] Qin-Liang Lin; Shun-Zheng Yu, "*A Distributed Green Networking Approach for Data Center Networks*", IEEE Communications Letters, Volume: 21, Issue: 4, pp 797-800, 2017.

[14] Seema Rawat, Praveen Kumar, Seemant Sagar, Iqbal Singh, Kartikay Garg; "*An analytical evaluation of challenges in Green cloud computing*" , 2017 International Conference on Infocom Technologies and Unmanned Systems (Trends and Future Directions) (ICTUS), pp 351-355,2017,IEEE Conferences.

[15] Umesh Singh, Amarendra K Singh, Parvez S and Anand Sivasubramaniam "*CFD-Based Operational Thermal Efficiency Improvement of a Production Data Center"*, Tata Consultancy Services Ltd., India

[16] K. Leigh and P. Ranganathan, "*Blades as a general-purpose infrastructure for future system architectures: Challenges and solutions*," HP Labs Tech. Rep. HPL-2006-182, Jan 2007.

[17] Hui Dou; Yong Qi, "*Greening Data Centers within Cost Budget"*, 2015 IEEE International Conference on Smart City/SocialCom/SustainCom (SmartCity), pp 568-574, 2015.